FORM 12-76 490 USE PREVIOUS EDITIONS

ARCHIVES/RECORDS CENTER SERVICE REQUEST

INSTRUCTIONS: REQUESTER — 1. COMPLETE REQUEST. 2. RETAIN LAST COPY FOR SUSPENSE. 3. SEND REST OF SET TO RECORDS CENTER. 4. UPON RECEIPT OF MATERIAL DESTROY SUSPENSE COPY. SIGN AND RETURN ORIGINAL TO RECORDS CENTER, IF APPLICABLE.

FROM: **ARCHIVES/RECORDS CENTER**

NO. A/I-16

DATE SERVICED

DATE

BOX NUMBER 16

JOB NUMBER 75-2153

ACTION REQUESTED: LOAN / PER. RETENT. / INFORMATION

TO: [redacted]

212 So. Bldg

NAME OF REQUESTER

STAT

OFFICE OTS

TEL. EXTENSION [redacted]

STAT

LOG DATA

MATERIAL REQUESTED IS TO BE USED FOR *(check one)*: FOIA / PRIVACY ACT / COMMITTEE INVESTIGATIONS / OTHER

FOR ARCHIVES/RECORDS CENTER USE

SERVICED BY EA

SPACE NUMBER

POSTED

NUMBER OF DOCUMENTS SENT 1

NOTIFIED

SECRET

PROGRESS REPORT NO. 1

CONTRACT NO. RD-53-SA

Research Order #1R&D4

Prepared by: [redacted] 50X1
Project Engineer

Approved by: [redacted] 50X1
Chief Engineer

[redacted] 50X1

Period Covered by this Report - November 5, 1953 to January 31, 1954

Copy #2

SECRET

INTRODUCTION

The purpose of the project is to investigate the advantages of pulse modulation, specifically as applied toward security and increased range of transmission with application to miniature transmitters.

A careful study of the available literature pertaining to pulse modulation was made in preparation for the actual design of equipment. A compilation of reference literature is included in this report.

The report describes the initial work done on the first pulse system investigated. A Pulse Amplitude Modulation System was designed and constructed. Tests were performed on the pulse generator, modulator and demodulator.

DISCUSSION

There are a number of features inherent in pulse modulation that do not appear in the more conventional amplitude modulation and frequency modulation systems. Some possible advantages of pulse modulation are: Improved signals to noise; increased range of transmission; since pulse power is utilized; and greater security, inasmuch as special receivers are required. Furthermore, there is a possibility of combining systems, such as pulsed frequency modulation, for additional security.

There are various pulse modulation systems that have been developed in the field. Among these are found: Pulse amplitude; pulse time or pulse position, which in a modified form is pulse phase modulation; pulse width or pulse duration modulation; as well as pulse code modulation. Equipment will be designed and comparative tests performed for the various pulse systems.

PULSE AMPLITUDE MODULATION

The first system to be considered was pulse amplitude modulation (P.A.M.). The design and experimentation described in this report was on the basis of a P. A. M. system. The following is a description of the equipment which was developed.

Reference to Figure 1, will indicate the general outline of a pulse amplitude modulated transmitter. The first section, Figure 3, is the pulse amplitude modulator. The first stage is a multivibrator. This determines the pulse repetition rate which was chosen as 8,000 cycles per second. A conservative design basis for the ratio of pulse repetition rate to highest audio frequency is 2.5. Using that as a criterion, the highest modulating frequency would be 3,200 cycles per second. This audio range is completely adequate for speech communication. In addition, this choice of pulse repetition rate enabled the use of uncomplicated filters at the receiver. On the basis of an 8,000 cycle per second repetition rate the pulse cycle occupied a 125 microsecond interval. The pulse width was chosen as 10 microseconds to provide an effective duty cycle for the transmitter.

The rise time of the pulse measured from the 10% to 90% amplitude points, was on the order of 0.5 microseconds. In order to pass the pulse without lengthening the rise time or otherwise distorting the shape, a video amplifier with a frequency response of 1 megacycle was required. In a similar manner the radio frequency stages should be designed to accommodate side bands of 1 megacycle. This requirement for wide bandwidth is the greatest disadvantage of commercial pulse communication systems. The bandwidth requirement can be,most readily met by the use of an ultra-high frequency or microwave system; in which case the ratio of bandwidth to carrier frequency would be negligibly small.

The multivibrator output was designed as a negative pulse. This was fed into a saturated amplifier, which acted as a limiter and shaper. The output of the limiter provided a positive well shaped pulse. The third stage was a dual-grid gated tube. The pulse was placed on the limiter grid of the gated tube. The audio signal was fed into the quadrature grid of the gated tube. The output was a pulse whose amplitude varied with the audio amplitude, at a rate determined by the frequency of the audio signal; and was single polarity pulses. This P.A.M. signal was passed to the final stage, a cathode follower, which in turn provided a low impedance output to the transmission line feeding the R.F. section.

The R.F. section, Figure 4, consists of an R.F. oscillator, amplifier, power amplifier and modulator. The R.F. oscillator was crystal controlled for frequency stability. Its output was lightly coupled to a buffer amplifier. The third stage, R.F. power amplifier, was grid modulated. Grid modulation was chosen as the most practical method, inasmuch as the amplitude of the modulating signal available was limited. The output of this stage was an R.F. carrier, pulse amplitude modulated. The modulator received and amplified P.A.M. signals. A pulse transformer coupled its output to the grid of the R.F. power amplifier for grid modulation.

Figure 2 is a block diagram of the receiver section of the system. The first block represents part of a commercial Hammarlund receiver HQ-129-X. It was decided to use this to take advantage of existing stages. The first stage was an R.F. amplifier or pre-selector. This tuned to the R.F. carrier which was modulated with a P.A.M. signal. The second stage was the converter, and stages 3 and 4 were the first and second I.F. amplifiers. The tube of stage 5, or third I.F. amplifier, was replaced by a plug-in vector chassis. A receiver will be designed to accommodate the wide bandwidth requirement.

Figure 5 is a schematic diagram of the plug-in unit. The first stage was the replacement tube for the third I.F. amplifier of the receiver. The second stage was a cathode follower which provided a low impedance output to the coaxial cable that connected with the demodulator chassis. This output signal was an I.F. carrier with P.A.M. modulation.

Figure 6 is the final chassis in the receiver section. The first stage was an I.F. amplifier. This coupled the signal to a conventional I.F. detector, whose output was amplitude modulated pulses. The second half of this stage was a video amplifier which increased the P.A.M. signal. Following the second stage was a low pass filter which acted as a demodulator, separating the pulse from the audio signal. For additional filtering a twin-T-filter tuned to 8,000 cycles per second completely eliminated the pulse repetition frequency. The last stage was an audio power amplifier, which in turn fed an external loudspeaker.

It is usual in the design of pulse demodulators to accommodate distortion resulting from "aperture effect". This pertains to the theory that a pulse which is infinitesimally narrow has a flat frequency response, whereas pulses of finite duration do not. To compensate for the distortion of pulse shape introduced by virtue of stages of limited bandwidth, it is conventional to include equalizers in the demodulator sections.

However, the pulse used in this equipment had a repetition rate of 8,000 cycles per second, or a cycle interval of 125 microseconds. The pulse width was 10 microseconds or 8 per cent of the pulse cycle. This made it possible to ignore the usual requirements for equalization due to aperture effect. An excellent discussion of this is found in "Modulation Theory," by H. S. Black.

REFERENCE STUDY

A careful study was made of available literature on pulse modulation. It was found that most of the articles were concerned with methods and systems of multiplexing. The primary problems of multiplexing are bandwidth, cross modulation and synchronization. These are of no particular concern in this investigation, since we are dealing with a single communication channel.

The articles directly relating to this work were primarily concerned with pulse time modulation. The most complete reference was "Modulation Theory," by H. S. Black. This text was used as the basis for theoretical analysis and design of equipment.

The following papers were of particular interest. They are numbered in accordance with their listing in the bibliography.

#4 - "New Method of Wide Band Modulation of Pulses" by Parks and Moss.

The authors describe a system of pulse-width modulation, including design criteria for modulators and demodulators.

#7 -"Time Modulation" - By B. Chance

and

#8 - "Time Demodulation" - by: The same author.

The articles concern the analysis and design of pulse position modulator and demodulator.

#20 - "Multi-Channel Communication Systems" By: Roberts and Simonds

The authors discuss the various methods of pulse modulation; emphasizing the advantages and disadvantages of each as applied to multi-channel systems.

CONCLUSIONS AND FUTURE WORK

The reference study of available literature on pulse modulation was useful from the viewpoint of theory and analysis. Nevertheless, it did not provide practical circuitry that could be incorporated in the system.

Equipment was designed for a pulse amplitude modulation system. The audio signal was properly reproduced at the demodulator on a closed circuit basis. In these tests the modulator chassis was connected directly to the demodulator unit.

It is planned to complete the adjustment of the transmitter. The equipment will be tested on a system basis. Further, video amplifiers will be designed. These amplifiers, used in conjunction with the pulse amplitude modulator will result in sufficient P. A. M. signal to enable high level modulation at the transmitter. This, in turn, will result in greater peak carrier power output.

In addition, and concurrent with the work on the P. A. M. system, a pulse time modulation system will be designed. Equipment will be built for a direct comparison of the results with the P. A. M. system.

SECRET

PULSE AMPLITUDE MODULATED TRANSMITTER

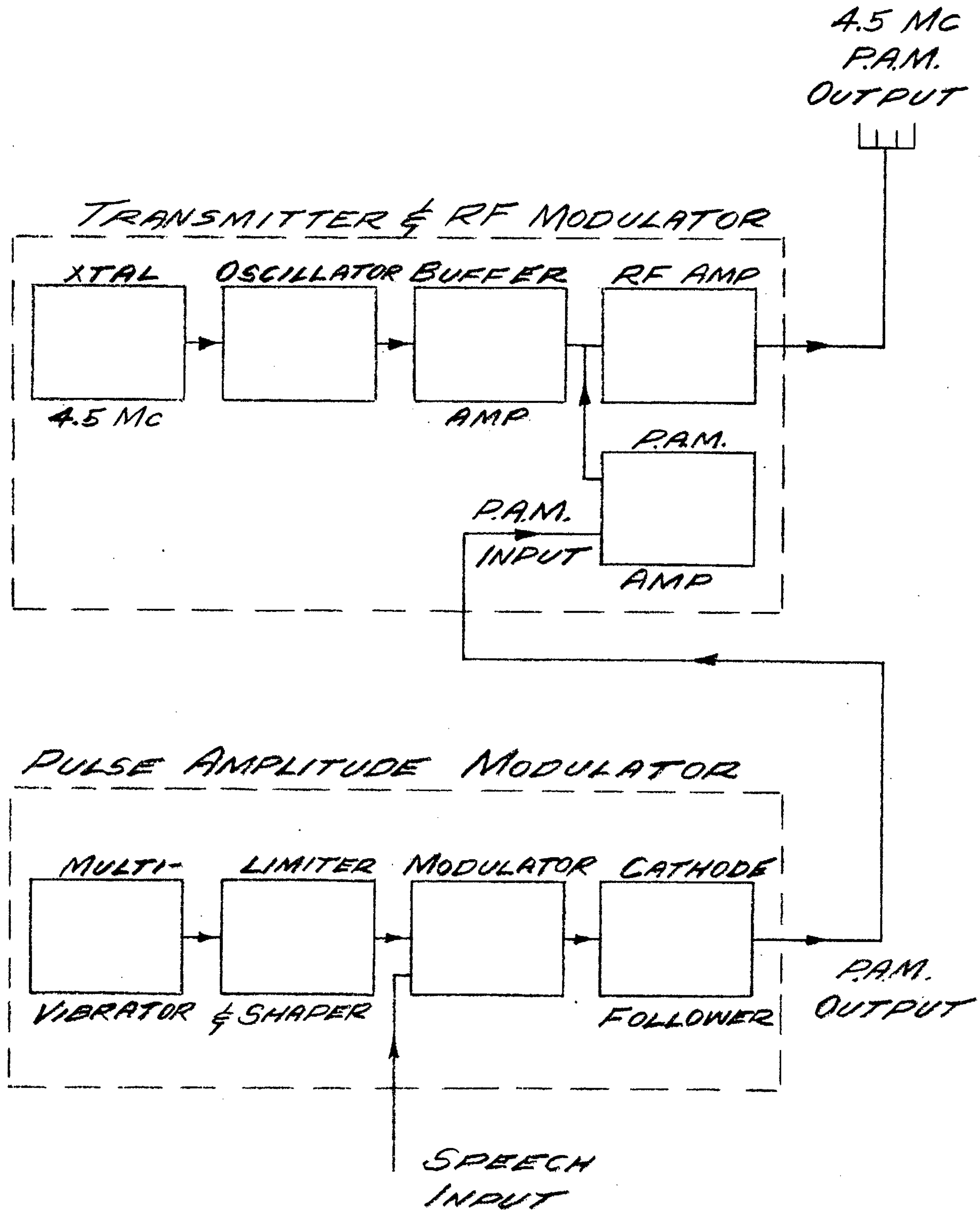


FIG. 1

SECRET

PULSE AMPLITUDE MODULATED RECEIVER

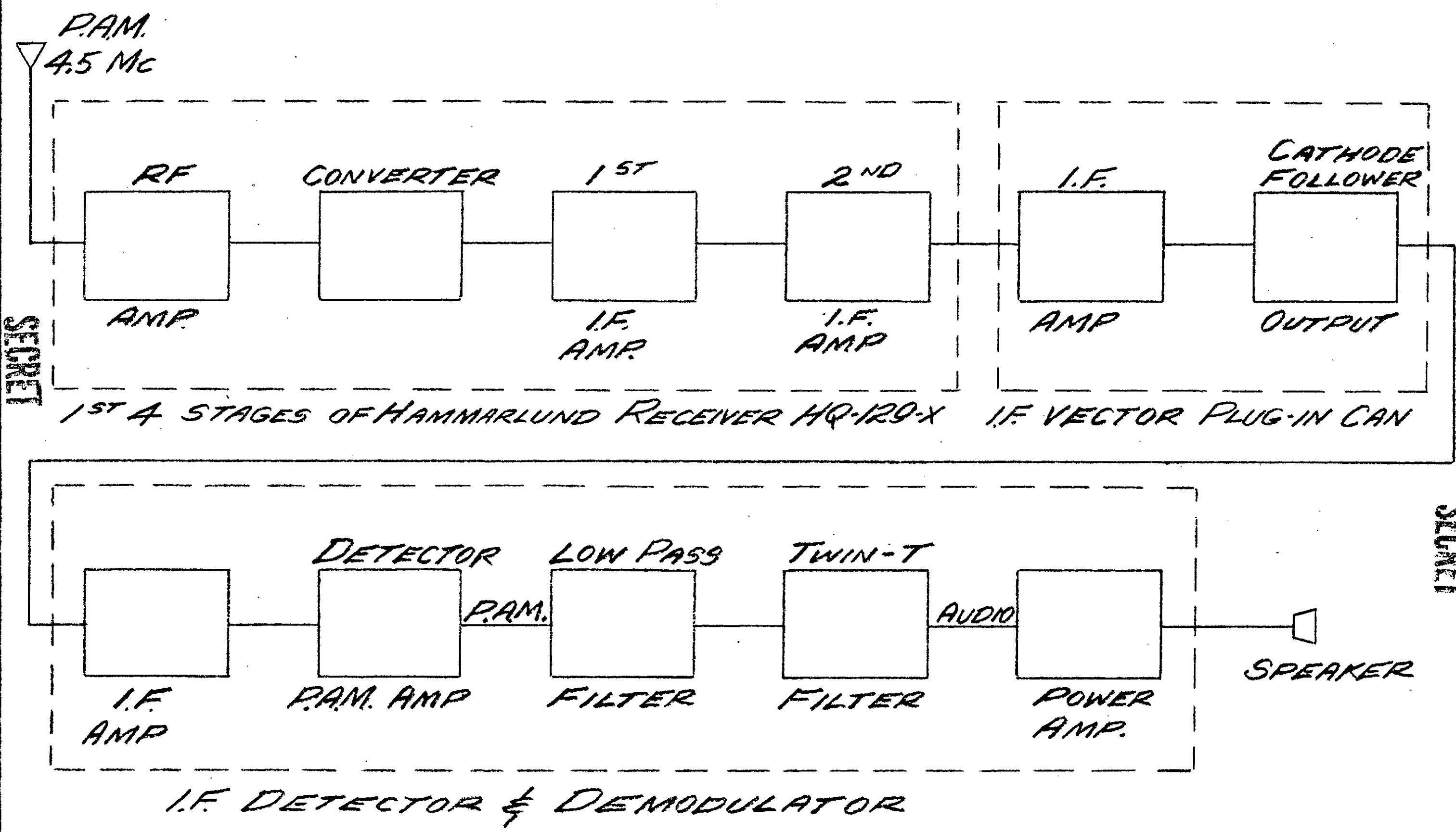
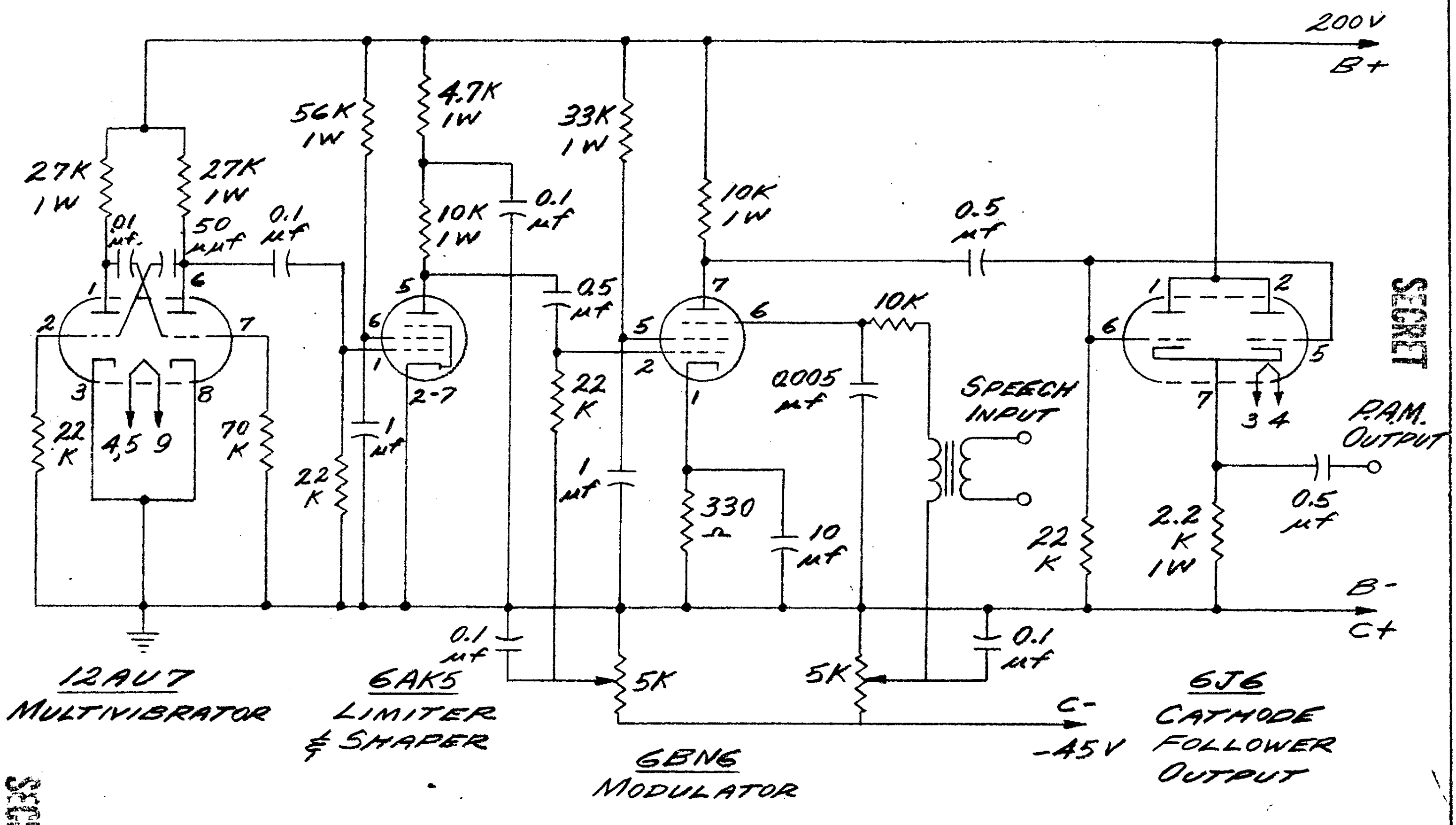


FIG. 2

SECRET



PULSE AMPLITUDE MODULATOR

FIG. 3

SECRET

4.5 MC TRANSMITTER - MODULATED WITH PAM

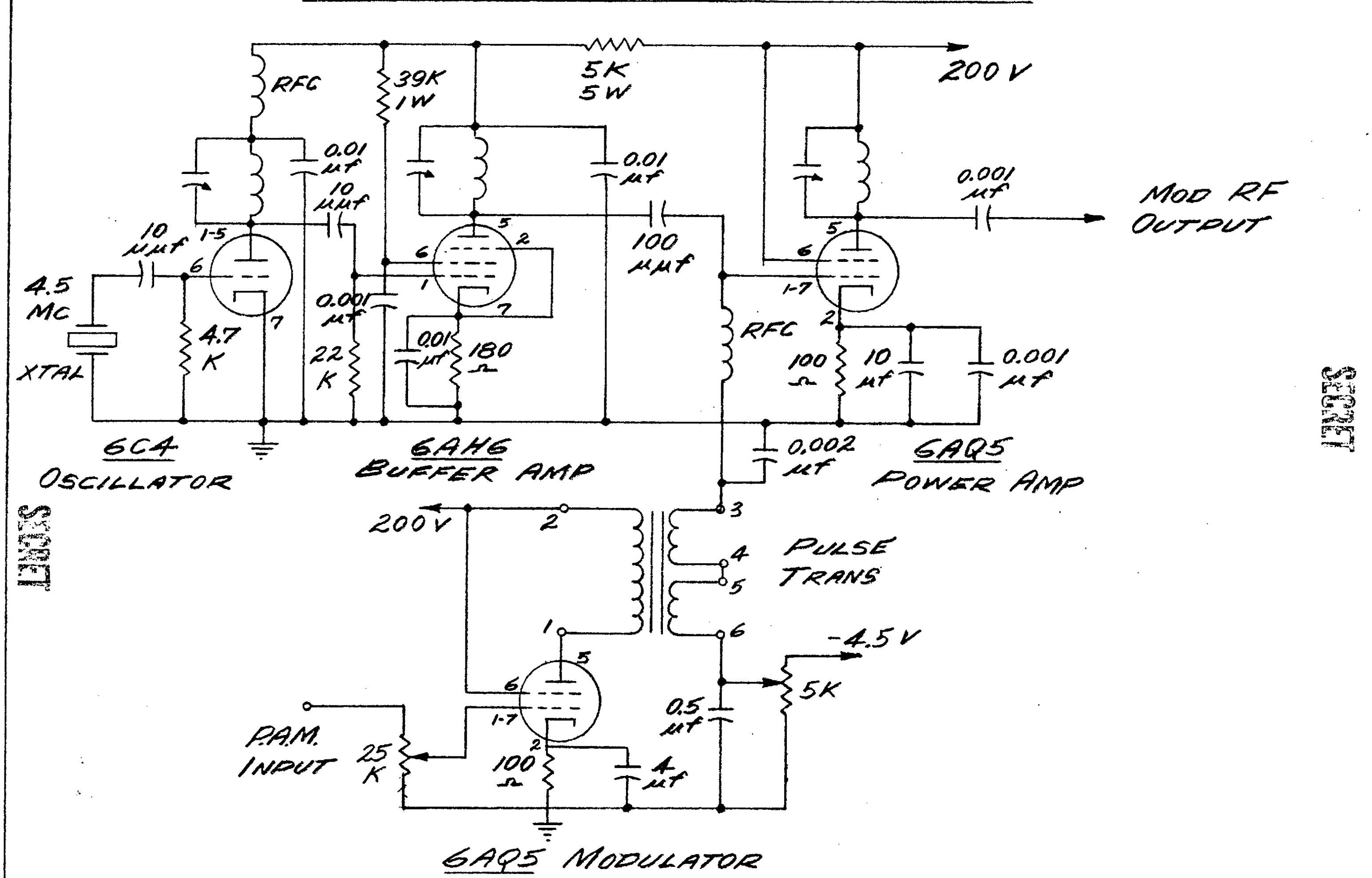


FIG. 4

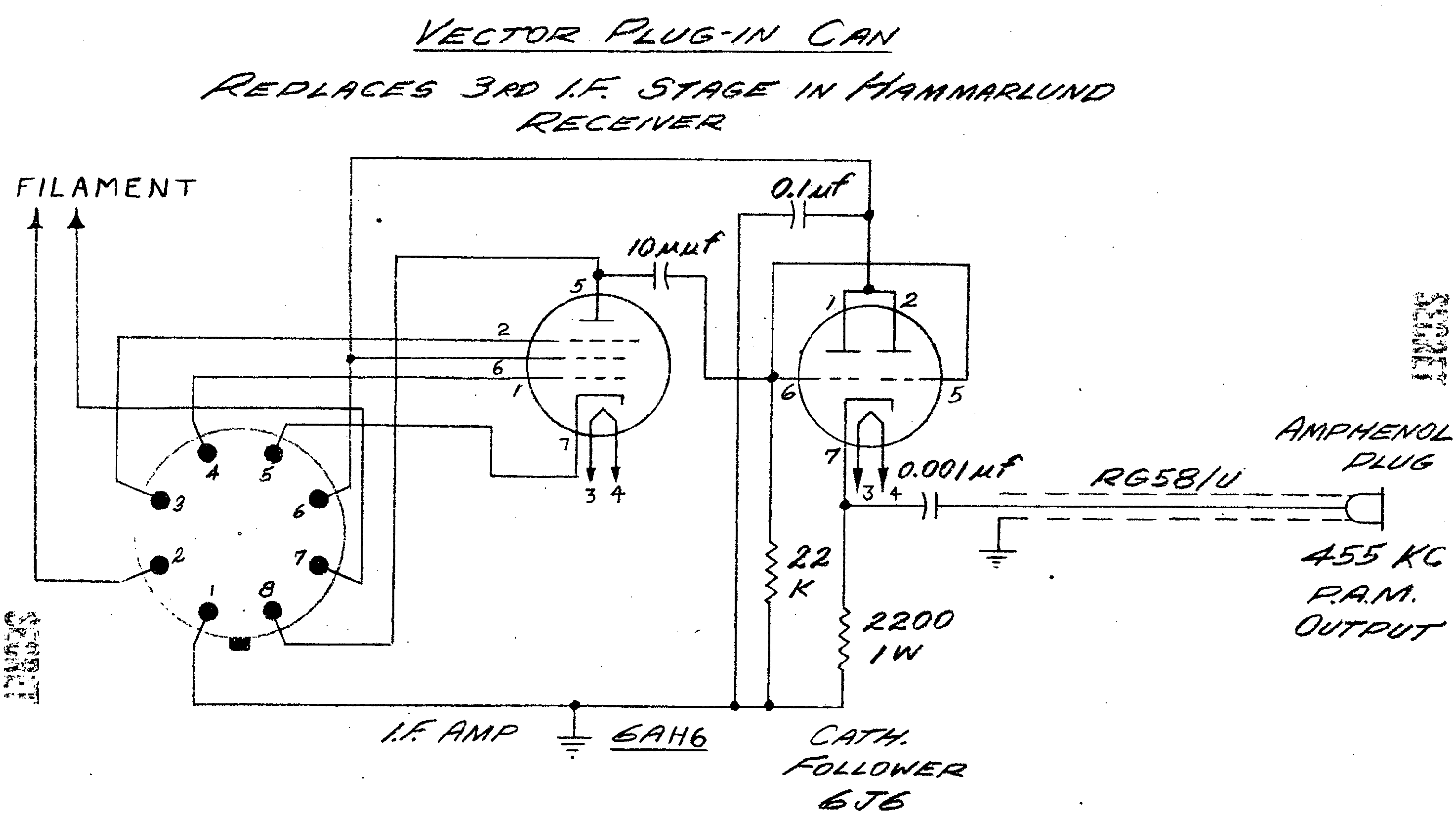

VECTOR PLUG-IN CAN
REPLACES 3RD I.F. STAGE IN HAMMARLUND RECEIVER
FILAMENT
0.1µf
10µµf
0.001µf
RG58/U
AMPHENOL PLUG
455 KC
P.A.M.
OUTPUT
22 K
2200 1W
I.F. AMP
6AH6
CATH. FOLLOWER
6J6

FIG. 5

SECRET

P.A.M. DEMODULATOR

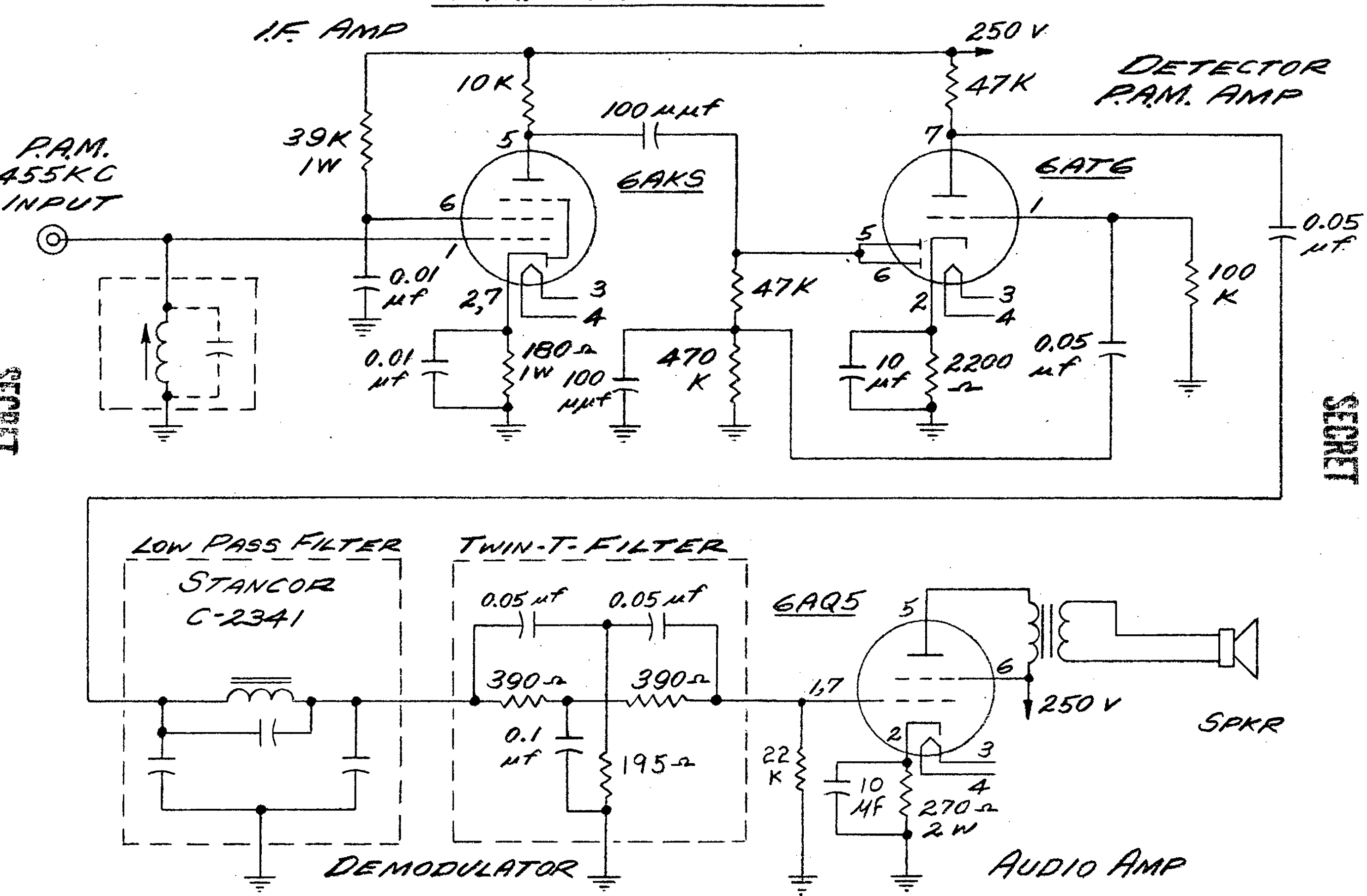


FIG. 6

SECRET

BIBLIOGRAPHY

	Title	Author	Publication	Date
1.	A Note on Pulse Codes	C. M. Sweet	Inst. Radio Eng. Proceedings	Feb. '53
2.	Bandwidth & Transmission Performance	W. R. Bennett C.B.Feldman	Bell System Technical Journal	July '49
3.	Multiplex Employing Pulse-Time and Pulsed Frequency Modulation	H. Goldberg C. C. Barth	Inst. Radio Eng. Proceedings	Jan. '49
4.	New Method of Wide Band Modulation of Pulses	G.H.Parks S.H.Moss	Inst. of Elec. Eng. Journal	Vol.94 III A 1947
5.	Common-Wave Duplex Pulse Communication System	J.H.McGuire P.J. Nowacki	Inst. of Elec. Eng. Journal	Vol.94 III A 1947
6.	A 60 CM. Multi-Channel System Employing Pulse Phase Modulation	D. D. Grieg	Inst. of Elec. Eng. Journal	Vol.94 III A 1947
7.	Time Modulation	B.Chance	Inst. Radio Eng. Proceedings	Oct. '47
8.	Time Demodulation	B.Chance	" " "	Oct. '47
9.	Pulse Count Modulation	D. D. Grieg	Electrical Communications	Sep. '47
10.	Pulse-Time-Modulated Multiplex Radio Relay System	D. D. Grieg H. Gallay	" " "	June '47
11.	Multi-Channel Microwave Radio Relay System	H.S.Black J. W. Beyer T. J. Grieser F.A.Polkinghorn	Electrical Engineering	Dec. '46
12.	Pulse Time Division Radio Relay	B. Trevor O. Dow Wm. D. Houghton	R.C.A. Review	Dec. '46
13.	Pulse Modulation	A. S. Gladwin	Wireless Engineering	Oct. '46
14.	Development of Radio Relay Systems	C. W. Hansell	R.C.A. Review	Sep. '46
15.	Pulse Modulating System	Wm. R. Greer	Electronics	Sep. '46

Bibliography (Cont'd.)

	Title	Author	Publication	Date
16.	Multi-Channel Pulse Modulation	Editorial Staff	Wireless World	June '46
17.	Pulse Time Modulated Multiplex Radio Relay System Terminal Equipment	D.D.Grieg A. M. Levine	Electrical Communications	June '46
18.	Pulse Modulated Radio Relay Equipment	J.J.Kelleher	Electronics	May '46
19.	Multiplex Broadcasting	D. D. Grieg	Electrical Communications	Mar. '46
20.	Multi-Channel Communication Systems	F.F.Roberts J.C.Simmonds	Wireless Engineering	Nov. '45
21.	Pulse Time Modulation	E.M.Deloraine E. Labin	Electronics	Jan. '45
22.	Time Division Multiplex Systems	W. R. Bennett	Bell System Technical Journal	Apr. '41
23.	Copper Oxide Modulators In Carrier Telephone Systems	R. S. Caruthers	" " "	Apr. '39
24.	Equivalent Modulator Circuits	E. Peterson L. W. Hussey	" " "	Jan. '39
25.	New Results in the Calculation of Modulation Products	W. R. Bennett	" " "	Apr. '33
26.	Certain Factors Affecting Telegraph Speed	H. Nyquist	" " "	Apr. '24

BOOKS

Modulation Theory	Harold S. Black D. Van Nostrand	
Radio Engineering	F. E. Terman - 3rd Ed. McGraw Hill	
Reference Data For Radio Engineers	3rd Edition, Federal Tel. & Radio Corp.	